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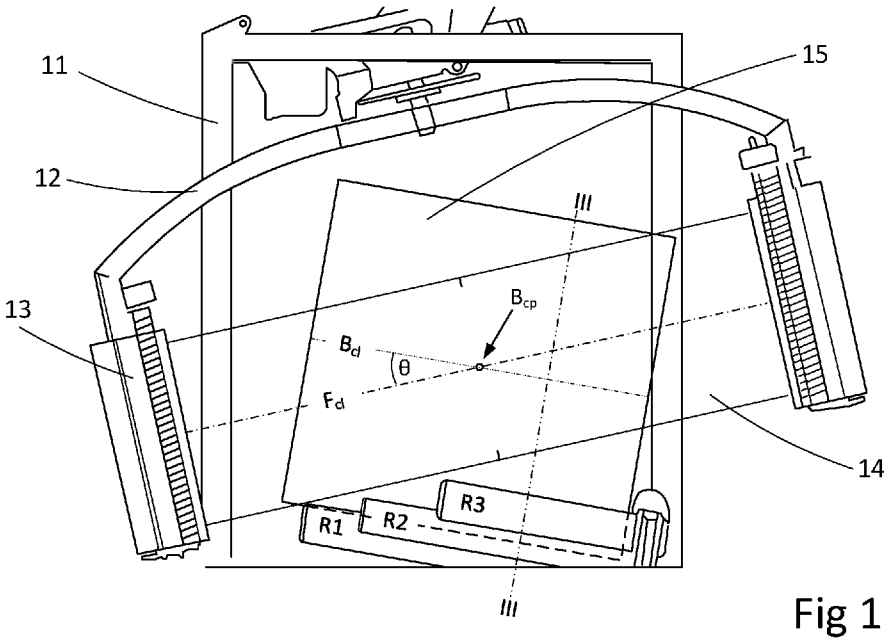


Fig 1

(57) **Abstract:** Foil wrapping device (10) for wrapping foil (14) around a cylindrical object (15) of a given size, comprising wrapping arms (12) and a wrapping table comprising pairs of powered support rollers (R1, R2, R3) The wrapping arms (12) are arranged to wrap layers of foil partly overlapping one another on the object by rotating one of the wrapping arms (12) and the wrapping table. The wrapping arms (12) are arranged such that a centre line ($F_{cl}$) of the foil (14) is stretched to the cylindrical object (15) at an angle (θ) in the region between 15 and 45 degrees with the length axes of the support rollers (R1, R2, R3). In one aspect, the centre line ($F_{cl}$) of the foil passes the centre point ($B_{cp}$) of the cylindrical object with a maximum deviation of less than 10 % of the diameter of the cylindrical object. In another aspect, the support rollers are arranged with a maximum relative length extension $R_e(N)$ as percentage of the length of the cylindrical object (15), as defined by the equation: $R_e(N) < 105 - 1.4\ \varphi_N$, where $R_e(N)$ is the extension of the support roller (N) in question as a

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percentage of the length of the cylindrical object (15), $\varphi_N$ is the angular position of the support roller R(N) in degrees from a vertical line through the centre of the cylindrical object (15).

# FOIL WRAPPING DEVICE

The present invention concerns a foil wrapping device for cylindrical objects as indicated by the preamble of claim 1, for example cylindrical bales or cylinders of consolidated material.

## Background

Conventional plastic foil bale wrapping devices have a supportive surface underneath the bale, often referred to as a wrapping table, and means of achieving relative rotation between the bale and at least one film roll. The relative rotation could either be due to a stationary bale, and a moving film roll, or vice versa. This movement must not be confused with the rotation the bale has around its own axis as will be explained in the figure discussion for figure 1. The present invention will be applicable to both these scenarios, and a combination of those. A device for stretching the film is often equipped on the film rolls in order to apply the film tightly without wrinkles, and with increased structural hold of the bale. The bale might be wrapped previously in either a net or a wider plastic film that covers the entire curved surface. The net or this wide plastic film is applied while the bale is in the chamber. It is still necessary to wrap the film further in order to seal the ends of the bale, as well as increasing the thickness at the curved surface. This secondary wrapping process is the one described in this device.

During wrapping the bale is slowly turned around its own axis on the wrapping table at a speed adapted to the rotational velocity film roll, to ensure a certain overlap of the foil from one turn to the next. Due to the geometry of conventional wrapping methods, where every layer of film will wrap the centre of the bales side surfaces, but only a small portion of the edges of said side surfaces, much more plastic film foil will be applied in the centre of the sides than on the edges. In order to obtain a foil wrapped bale with at least 6 layers of foil at every point of the bale, the centre of the sides of the bale is provided with approximately 27 layers of foil with this known arrangement, depending on the bale size (this is for bales with diameter 1150mm and width 1200mm) and standard width of the plastic film of 750mm. This means that an excessive amount of plastic foil, and number of rotations of the film roll, is necessary to achieve a certain coverage, which is very unsuitable for the environment in terms of plastic consumption, but also for the efficiency of the wrapping process. The number of layers is essential for the preservation of the bales' material, where more layers give a better preservation. If the bale is covered as the example above, with 27 layers in the central cluster, and 6 at the edges, the edges will be the point of leakage and thus the limiting factor for the quality of the bales' preservation.

**Objectives**

It is an objective of the present invention to provide a foil wrapping device suitable for use on cylindrical objects, such as bales of fodder and the like. It is a specific objective that the device is effective with regard to the amount of foil consumed in the process and with regard to the time and energy spent for the process.

**Summary of Invention**

According to a first aspect of the invention, there is provided a foil wrapping device (10) for wrapping foil (14) around a cylindrical object (15) of a predetermined length and diameter, comprising:
at least one wrapping arm (12) arranged to hold rolls (13) of foil (14) and a wrapping table comprising a plurality of support rollers (R1, R2, R3) with parallel length axes, wherein at least one of the support rollers is a powered roller;
said wrapping table being arranged to support and rotate the cylindrical object (15) with the predetermined length and diameter placed upon the wrapping table when the axis (Bcl) of the cylindrical object (15) is parallel with the length axes of the support rollers;
said cylindrical object (15) being defined by a peripheral surface and two circular surfaces, having an axis (Bcl) between the centres of the two circular surfaces and a centre point (Bcp) on said axis at equal distance from each of said circular surfaces;
the at least one wrapping arm (12) being arranged to stretch foil (14) across the cylindrical object (15) and to wrap it in layers of foil partly overlapping one another by rotating the at least one wrapping arm (12) or the wrapping table;
characterized in that:
the wrapping arms (12) are arranged such that a centre line (Fcl) of the foil (14) being stretched to the cylindrical object (15) is at an angle θ in the region between 15 and 45 degrees with the length axes of the support rollers (R1, R2, R3);
and that a centre line (Fcl) of the foil passes a centre point (Bcp) of the cylindrical object with a maximum deviation of less than 10 % of the diameter of the cylindrical object.

According to a second aspect of the invention, there is provided a foil wrapping device (10) for wrapping foil (14) around a cylindrical object (15) of a predetermined length and diameter, comprising:

at least one wrapping arms (12) arranged to hold rolls (13) of foil (14) and a wrapping table comprising a plurality of support rollers (R1, R2, R3) with parallel length axes, wherein at least one of the support rollers is a powered roller;

said wrapping table being arranged to support and rotate the cylindrical object (15) with the predetermined length and diameter placed upon the wrapping table when the axis (Bcl) of the cylindrical object (15) is parallel with the length axes of the support rollers;

said cylindrical object (15) being defined by a peripheral surface and two circular surfaces, having an axis (Bcl) between the centres of the two circular surfaces and a centre point (Bcp) on said axis at equal distance from each of said circular surfaces;

the at least one wrapping arm (12) being arranged to stretch foil (14) across the cylindrical object (15) and to wrap it in layers of foil partly overlapping one another by rotating the at least one wrapping arm (12) or the wrapping table;

characterized in that:

the at least one wrapping arm (12) is arranged such that a centre line (Fcl) of the foil (14) being stretched to the cylindrical object (15) is at an angle θ in a range between 15 and 45 degrees with the length axes of the support rollers (R1, R2, R3) and

the support rollers are arranged with a maximum relative length extension Re(N) as percentage of the length of the cylindrical object (15), as defined by the equation:

$$Re(N) < 105 - 1.4\,\phi N$$

where

Re(N) is the extension of the support roller (N) in question as a percentage of the length of the cylindrical object (15),

ϕN is the angular position of the support roller R(N) in degrees from a vertical line through the centre of the cylindrical object (15).

According to a third aspect of the invention, there is provided a method of wrapping foil around a cylindrical object, the method comprising:

- supporting the cylindrical object on a wrapping table comprising a plurality of support rollers (R1, R2, R3) with parallel length axes, wherein at least one of the support rollers is a powered roller;
- rotating the cylindrical object (15) on the wrapping table with an axis ($B_{cl}$) of the cylindrical object (15) is parallel with the length axes of the support rollers;
- holding a roll of foil on at least one wrapping arm, and rotating the at least one wrapping arm (12) or the wrapping table to stretch foil (14) across the cylindrical object (15) and to wrap it in layers of foil partly overlapping one another;

**characterized in** that:

the wrapping arms (12) are arranged such that a centre line ($F_{cl}$) of the foil (14) being stretched to the cylindrical object (15) is at an angle θ in the region between 15 and 45 degrees with the length axes of the support rollers (R1, R2, R3);

and a centre line ($F_{cl}$) of the foil passes a centre point ($B_{cp}$) of the cylindrical object with a maximum deviation of less than 10 % of the diameter of the cylindrical object.

According to a fourth aspect of the invention, there is provided a method of wrapping foil around a cylindrical object, the method comprising:

- supporting the cylindrical object on a wrapping table comprising a plurality of support rollers (R1, R2, R3) with parallel length axes, wherein at least one of the support rollers is a powered roller;
- rotating the cylindrical object (15) on the wrapping table with an axis ($B_{cl}$) of the cylindrical object (15) is parallel with the length axes of the support rollers;
- holding a roll of foil on at least one wrapping arm, and rotating the at least one wrapping arm (12) or the wrapping table to stretch foil (14) across the cylindrical object (15) and to wrap it in layers of foil partly overlapping one another;

**characterized in** that:

the at least one wrapping arm (12) is arranged such that a centre line ($F_{cl}$) of the foil (14) being stretched to the cylindrical object (15) is at an angle θ in a range between 15 and 45 degrees with the length axes of the support rollers (R1, R2, R3) and

the support rollers are arranged with a maximum relative length extension $R_e(N)$ as percentage of the length of the cylindrical object (15), as defined by the equation:

$$R_e(N) < 105 - 1.4\,\phi_N$$

where

$R_e(N)$ is the extension of the support roller (N) in question as a percentage of the length of the cylindrical object (15),

$\phi_N$ is the angular position of the support roller R(N) in degrees from a vertical line through the centre of the cylindrical object (15).

Preferred embodiments of each aspect of invention are disclosed by the dependent claims. Preferred and optional features of the third and fourth aspects of the invention correspond to preferred and optional features of the first and second aspects of the invention and vice versa.

It should be noted that, with regard to claim definition, wherever there is a mention of a (or *the*) cylindrical object to be wrapped, the reference is to *any imaginary object of a length and diameter for which the device is designed*, since the cylindrical object in question – as such – is not part of the present invention. The various features of the device are hardly possible to describe without including their intended interaction with an (imaginary) object positioned in the device. Thus, it should not be interpreted in any part of the definition of the wrapping device that a cylindrical object actually needs to be present for the definition to be valid.

The device according to an aspect of the present invention is arranged to apply film with an inclination angle θ between the foil applied and the wrapping table. The angle θ of inclination is typically between 15 and 45 degrees, more preferred between 20 and 35 degrees but may depart from these limits within the scope of alternative aspects of the present invention. The inventive arrangement provides a convenient distribution of film due to decreased clustering in the centre of the sides of the bale compared to conventional wrapping methods and apparatuses. The present invention will rather apply more film towards the periphery of the circular end surfaces, thus reducing the centre clustering, which results in a lower total foil consumption for a given minimum number of applied film layers.

According to a fifth aspect of the invention, the above indicated objective is achieved by a foil wrapping device (10) for wrapping foil (14) around a cylindrical object (15) of a predetermined length and diameter,

comprising wrapping arms (12) arranged to hold rolls (13) of foil (14) and a wrapping table comprising pairs of powered support rollers (R1, R2, R3) with parallel length axes,

said wrapping table being arranged to support and rotate the cylindrical object (15) with the predetermined length and diameter placed upon the wrapping table when the axis ($B_{cl}$) of the cylindrical object (15) is parallel with the length axes of the support rollers,

said cylindrical object (15) being defined by a peripheral surface and two circular surfaces, having an axis ($B_{cl}$) between the centres of the two circular surfaces and a centre point ($B_{cp}$) on said axis at equal distance from each of said circular surfaces,

the wrapping arms (12) being arranged to stretch foil (14) across the cylindrical object (15) and to wrap it in layers of foil partly overlapping one another by rotating one of the wrapping arms (12) and the wrapping table, **characterized in** that

the wrapping arms (12) are arranged such that a centre line ($F_{cl}$) of the foil (14) being stretched to the cylindrical object (15) is at an angle θ in the region between 15 and 45 degrees with the length axes of the support rollers (R1, R2, R3)

and that the centre line ($F_{cl}$) of the foil passes the centre point ($B_{cp}$) of the cylindrical object with a maximum deviation of less than 10 % of the diameter of the cylindrical object.

According to a sixth aspect of the present invention, there is provided a foil wrapping device (10) for wrapping foil (14) around a cylindrical object (15) of a predetermined length and diameter,
comprising wrapping arms (12) arranged to hold rolls (13) of foil (14) and a wrapping table comprising pairs of powered support rollers (R1, R2, R3) with parallel length axes,
said wrapping table being arranged to support and rotate the cylindrical object (15) with the predetermined length and diameter placed upon the wrapping table when the axis ($B_{cl}$) of the cylindrical object (15) is parallel with the length axes of the support rollers,
said cylindrical object (15) being defined by a peripheral surface and two circular surfaces, having an axis ($B_{cl}$) between the centres of the two circular surfaces and a centre point ($B_{cp}$) on said axis at equal distance from each of said circular surfaces,
the wrapping arms (12) being arranged to stretch foil (14) across the cylindrical object (15) and to wrap it in layers of foil partly overlapping one another by rotating one of the wrapping arms (12) and the wrapping table, **characterized in** that
the wrapping arms (12) are arranged such that a centre line ($F_{cl}$) of the foil (14) being stretched to the cylindrical object (15) is at an angle θ in the region between 15 and 45 degrees with the length axes of the support rollers (R1, R2, R3) and that
support rollers are arranged with a maximum relative length extension $R_e(N)$ as per centage of the length of the cylindrical object (15), as defined by the equation:

$$R_e(N) < 105 - 1.4\,\phi_N$$

where
$R_e(N)$ is the extension of the support roller (N) in question as a per centage of the length of the cylindrical object (15),
$\phi_N$ is the angular position of the support roller R(N) in degrees from a vertical line through the centre of the cylindrical object (15).

It is a further criterion of aspects and embodiments of the invention that the device is arranged to apply the film with its centre line close to the centre point of any object being wrapped, deviating less than 10% of the diameter of the object, preferably less than 5% of the diameter of the object.

According to full scale test results in the form of a bale wrapper, using the foil wrapping device according to the present invention reduces the consumption of a standard 750 mm (plastic) foil by at least 50 % compared to the consumption of today's commercial foil wrappers. The amount of

wide film used remains unchanged (wide film being the plastic film applied to the bales curved (peripheral) surface inside the harvesting chamber, constituting about 25% of the total amount of film. This means the total foil reduction is about 40%, which is a considerable improvement in bale wrapping, with a significant positive environmental effect. The number of necessary rotations of the wrapping arms is reduced correspondingly, thereby improving the wrapping capacity vastly, as well as reducing the required energy consumption.

Below the invention is described in further detail in the form of non-limiting embodiments illustrated by the enclosed drawings, where:

Figure 1 is a schematic, simplified, transparent side view of an embodiment of a wrapping device according to the present invention;

Figure 2 is a schematic, simplified transparent side view of an embodiment of a wrapping device according to the present invention in a slightly different orientation;

Figure 3 is a schematic, simplified front view of some details of the wrapping device according to the present invention; and

Figure 4 is an enlarged side sectional view of some of the elements of Figure 1.

By schematic is understood that the components are not necessarily shown with mutually correct dimensions and by simplified is understood that certain components that may or will be present in a real life operational device, such as power supply, control systems, electric components, hydraulic components etc., which as such do not constitute inventive elements, are omitted.
In the following, a cylindrical object to be wrapped is for convenience referred to as a bale.

Figure 1 is a simplified, transparent side view of the central parts of a wrapping device 10 according to the present invention, comprising a chassis (11), wrapping arms 12 holding foil rolls 13 of plastic foil 14 being wrapped around a bale 15 resting on a wrapping table mainly consisting of three pairs of support rollers, R1, R2, R3. Only one roller of each pair is visible in the drawing, the other ones being hidden behind the ones shown and behind the bale 15. The support rollers will be rotatably arranged in order to be able to rotate the bale during packing. This is not to be confused with a rotation of the entire wrapping table around an imaginary axis perpendicular to the axes of the

support rollers, which is a non-mandatory feature of the present device, not described in further detail herein.

The bale is shown slightly tilted one way (to the right in the drawing) in relation to the support frame 11 while the wrapping arms 12 are tilted the other way, resulting in an angle θ between the centre line $B_{cl}$ of the bale and the centre line $F_{cl}$ of the foil being wrapped thereon. Figure 1 shows an ideal configuration of the device in the sense that the foil centre line $F_{cl}$ of passes through the bale centre point $B_{cp}$, i.e. through the exact centre of the bale. Adjustments of the table position, the wrapping arms' position and their respective degree of tilt will affect this configuration. The angle θ shown in Figure 1 is about 25 degrees. The centre line $B_{cl}$ is also designated the axis of the bale - or more generally – of a cylindrical object to be wrapped. Since the centre line of a cylindrical object properly arranged on the wrapping table will be parallel with the length axes of the support rollers, the angle θ may also be defined as the angle between the foil centre line and the length axes of the support rollers. This is in fact a more fundamental definition since the cylindrical object is not as such part of the present invention.

It is worth noticing that the support roller pair R1, close to the lowermost part of the bale, has an extension only slightly less than the bale length, leaving about 10% of the bale length unsupported. The second support roller pair R2 is significantly shorter, leaving about 25% of the bale length unsupported while the third support roller pair R3 is even shorter, leaving about 45% of the bale length unsupported. This arrangement of gradually shorter support rollers when moving from the lowermost part of the bale up to higher parts is of significance for allowing the desired manner of bale wrapping, using an angle θ between the foil centre line $F_{cl}$ and the bale centre line $B_{cl}$. As mentioned, the angle θ is preferably in the region 20 to 35 degrees. The reduced extension of the support rollers is required to avoid conflict thereof with the foil to be wrapped.

While the angle θ is the parameter of interest for the wrapping geometry of the present invention, its contribution from tilting of the wrapping table is primarily for the sake of ensuring that the partly unsupported bale or another cylindrical object does not slide off the wrapping table. The wrapping table may have a permanently tilted orientation, or it may be arranged to shift between a more horizontal orientation and the shown tilted orientation e.g. by hydraulic means.

The broken line III – III in Figure 1 shows the section line at which Figure 3 is based.

Figure 2 shows principally the same as Figure 1, but in this case the bale is positioned somewhat lower, causing the centre line $F_{cl}$ of the foil to pass at a distance *d* above the bale centre point $B_{cp}$. A slight deviation from crossing of the foil centre line $F_{cl}$ through the bale centre point $B_{cl}$ is acceptable within the scope of the invention but the offset or deviation *d* should not exceed 10 % of the bale diameter and more preferred not more than 5% of the bale diameter.

Figure 3 is a schematic, simplified front sectional view of a bale 14 supported by three pairs of support rollers R1, R2, R3 as in Figures 1 and 2. The support rollers are all parallel to the bale centre line $B_{cl}$ which in Figure 3 is perpendicular to the paper plane. The longer support rollers R1 are rather close to a vertical line, $B_{vl}$ from the centre of the bale, at an angle $\phi_1$ typically in the range 10 to 20 degrees from the vertical line $B_{vl}$. The somewhat shorter support rollers R2 are positioned at an angle $\phi_2$ typically in the range 20 to 30 degrees from same vertical line. Finally, the shortest support rollers R3 are typically positioned at an angle $\phi_3$ in the range 30 – 45 degrees from the same vertical line.

It is not essential that there are three pairs of support rollers as illustrated, it may be just two pairs, or it may be even more than three pairs. More than three pairs are however usually not required and would make the overall design unnecessary complicated. Use of three pairs normally ensures sufficient support vertically and horizontally.

It should be noted, with reference still to Figure 3, that the support rollers are arranged in a manner defining part of an imaginary circle with a radius corresponding to the radius of the objects to be received and wrapped. This imaginary circle may be referred to independent of whether or not a cylindrical object is present on the support rollers of the wrapping table. Thus, when referring to “a vertical line through the centre of the cylindrical object”, the reference may as well be replaced by replaced by “a vertical line through the imaginary circle defined by the support rollers”. This denotation is more fundamental in the sense that it does not depend on a cylindrical object actually being present on the wrapping table.

Figure 4 is a side view of a few elements of the device, the support rollers, shown in the same way as in the more comprehensive drawings of Figure 1 and 2. Figure 4, in consideration of Figure 3, illustrates the correlation between the positions and the longitudinal extensions of the support rollers R1, R2, and R3. The lowermost pair of support rollers, R1, typically positioned at an angle in the range 10 to 20 degrees from the vertical line $B_{vl}$, has a relative longitudinal extension $R_e(1)$ of about 90% of the bale length. The second pair of support rollers, R2, typically positioned at an angle

in the range 20 to 30 degrees from same vertical line has a relative longitudinal extension $R_e(2)$ of about 75% of the bale length, while the third pair of support rollers R3, typically positioned at an angle $\phi_3$ in the range 30 – 45 degrees from the same vertical line has a relative longitudinal extension $R_e(3)$ of just about 55% of the bale length.

Thus, when considering Figures 3 and 4 combined, it is seen that there is an inverse correlation between the angle $\phi$ (in degrees) and the relative supported length extension $R_e(N)$ of the bale, N being an integer 1, 2 or 3 indicating which pair of support rollers the $R_e(N)$ refers to. The larger the angle $\phi$, the shorter the support roller.

This may be expressed mathematically in an equation constituting a mandatory feature of one specific aspect of the present invention, namely:

$$R_e(N) < N_{emp} - k\,\phi_N$$

where

$R_e(N)$ is the extension of the support roller in question as a per centage of the length of the cylindrical object,

*k* is a constant decided empirically

$\phi_N$ is the angular position of the support roller in degrees from a vertical line through the centre of the cylindrical object (or a vertical line through the imaginary circle defined by the support rollers),

$N_{emp}$ is an empiric number found in the development of the present invention.

It has been found that $N_{emp}$ is 105 and that k =1,4.

Thus, for a given pair of support rollers positioned at a given angle $\phi$ from the vertical line through the centre of the cylindrical object, the maximum relative extension $R_e$ of a support roller can be calculated.

As an example, for a roller (pair) arranged at $\phi_N$ = 35 degrees, the maximum relative length extension, $R_e(N)$ max (as per centage of the length of the cylindrical object) for the support roller is calculated as:

$R_e(N) < 105 – 1.4 \times 35 = 56$; i.e. $R_e(N) < 56$ % of the length of the cylindrical object.

It is preferred that the length extensions of the support rolls in practice are chosen within 80 to 100% of the calculated value for $R_e(N)$ and more preferred in the region 90 to 95% thereof.

To some extent, the functionality of the device depends also on the width of the foil to be applied. A narrow foil will require an excessive number of turns for wrapping the cylindrical object properly while an excessive width would come in conflict with the support rollers of the wrapping table. While fine-tuning of width in relation to a certain geometry (length and position of support rollers in combination with a specific angle θ) is possible, a sound choice covering a multitude of combinations may easily be found by a person skilled in the art. The foil width illustrated in Figure 1, constituting 58 % of the diameter of the cylindrical object, is within such general functional area useful for most geometries of the device.

The invention provides a foil wrapping device (10) for wrapping foil (14) around a cylindrical object (15) of a given size, comprising wrapping arms (12) and a wrapping table comprising pairs of powered support rollers (R1, R2, R3). The wrapping arms (12) are arranged to wrap layers of foil partly overlapping one another on the object by rotating one of the wrapping arms (12) and the wrapping table. The wrapping arms (12) are arranged such that a centre line ($F_{cl}$) of the foil (14) is stretched to the cylindrical object (15) at an angle θ in the region between 15 and 45 degrees with the length axes of the support rollers (R1, R2, R3). In one aspect, the centre line ($F_{cl}$) of the foil passes the centre point ($B_{cp}$) of the cylindrical object with a maximum deviation of less than 10 % of the diameter of the cylindrical object. In another aspect, the support rollers are arranged with a maximum relative length extension $R_e(N)$ as percentage of the length of the cylindrical object (15), as defined by the equation: $R_e(N) < 105 - 1.4\,\phi_N$ where $R_e(N)$ is the extension of the support roller (N) in question as a percentage of the length of the cylindrical object (15), $\phi_N$ is the angular position of the support roller R(N) in degrees from a vertical line through the centre of the cylindrical object (15).

**Claims**

1. Foil wrapping device (10) for wrapping foil (14) around a cylindrical object (15) of a predetermined length and diameter, comprising:

at least one wrapping arm (12) arranged to hold rolls (13) of foil (14) and a wrapping table comprising a plurality of support rollers (R1, R2, R3) with parallel length axes, wherein at least one of the support rollers is a powered roller;

said wrapping table being arranged to support and rotate the cylindrical object (15) with the predetermined length and diameter placed upon the wrapping table when the axis ($B_{cl}$) of the cylindrical object (15) is parallel with the length axes of the support rollers;

said cylindrical object (15) being defined by a peripheral surface and two circular surfaces, having an axis ($B_{cl}$) between the centres of the two circular surfaces and a centre point ($B_{cp}$) on said axis at equal distance from each of said circular surfaces;

the at least one wrapping arm (12) being arranged to stretch foil (14) across the cylindrical object (15) and to wrap it in layers of foil partly overlapping one another by rotating the at least one wrapping arm (12) or the wrapping table;

**characterized in** that:

the wrapping arms (12) are arranged such that a centre line ($F_{cl}$) of the foil (14) being stretched to the cylindrical object (15) is at an angle θ in the region between 15 and 45 degrees with the length axes of the support rollers (R1, R2, R3);

and a centre line ($F_{cl}$) of the foil passes a centre point ($B_{cp}$) of the cylindrical object with a maximum deviation of less than 10 % of the diameter of the cylindrical object.

2. Foil wrapping device (10) as claimed in claim 1, comprising a plurality of wrapping arms.

3. Foil wrapping device (10) as claimed in claim 1 or claim 2, wherein the support rollers are in pairs.

4. Foil wrapping device (10) as claimed in any preceding claim, wherein the support rollers are powered.

5. Foil wrapping device (10) as claimed in any preceding claim, wherein the device is configured to apply the foil across an edge of the cylindrical object.

6. Foil wrapping device (10) as claimed in any preceding claim, wherein the angle θ is within 20 and 35 degrees.

7. Foil wrapping device (10) as claimed in any preceding claim, wherein the centre line ($F_{cl}$) of the foil passes the centre point ($B_{cp}$) of the cylindrical object with a maximum deviation of less than 5 % of the diameter of the cylindrical object.

8. Foil wrapping device (10) as claimed in any preceding claim, comprising a pair of longer support rollers which support about 90% of the bale length.

9. Foil wrapping device (10) as claimed in any preceding claim, comprising a second, shorter support roller pair which support about 75% of the bale length.

10. Foil wrapping device (10) as claimed in any preceding claim, comprising a third support roller pair which support about 55% of the bale length.

11. Foil wrapping device (10) as claimed in any of claims 8 to 10, wherein the longer support rollers R1 are located on a radial line from the centre of the bale at an angle $\phi_1$ in the range 10 to 20 degrees from a vertical radial line $B_{vl}$ from the centre of the bale.

12. Foil wrapping device (10) as claimed in any of claims 9 to 11, wherein the second, shorter support rollers are located on a radial line from the centre of the bale at an angle $\phi_2$ in the range 20 to 30 degrees from a vertical radial line $B_{vl}$ from the centre of the bale.

13. Foil wrapping device (10) as claimed in any of claims 10 to 12, wherein the third support roller rollers located a radial line from the centre of the bale at an angle $\phi_3$ in the range 30 to 45 degrees from a vertical radial line $B_{vl}$ from the centre of the bale.

14. Foil wrapping device (10) as claimed in any preceding claim, wherein the support rollers are arranged with a maximum relative length extension $R_e(N)$ as percentage of the length of the cylindrical object (15), as defined by the equation:

$$R_e(N) < 105 - 1.4\,\phi_N$$

where

$R_e(N)$ is the extension of the support roller (N) in question as a percentage of the length of the cylindrical object (15); and

$\phi_N$ is the angular position of the support roller R(N) in degrees from a vertical line through the centre of the cylindrical object (15).

15. Foil wrapping device (10) as claimed any claim 14, wherein the lengths of the support rollers are within 80 to 100% of the calculated value for $R_e(N)$.

16. Foil wrapping device (10) as claimed in claim 15, wherein the lengths of the support rollers are within 90 to 95% of the calculated value for $R_e(N)$.

17. Foil wrapping device (10) for wrapping foil (14) around a cylindrical object (15) of a predetermined length and diameter, comprising:

at least one wrapping arms (12) arranged to hold rolls (13) of foil (14) and a wrapping table comprising a plurality of support rollers (R1, R2, R3) with parallel length axes, wherein at least one of the support rollers is a powered roller;

said wrapping table being arranged to support and rotate the cylindrical object (15) with the predetermined length and diameter placed upon the wrapping table when the axis ($B_{cl}$) of the cylindrical object (15) is parallel with the length axes of the support rollers;

said cylindrical object (15) being defined by a peripheral surface and two circular surfaces, having an axis ($B_{cl}$) between the centres of the two circular surfaces and a centre point ($B_{cp}$) on said axis at equal distance from each of said circular surfaces;

the at least one wrapping arm (12) being arranged to stretch foil (14) across the cylindrical object (15) and to wrap it in layers of foil partly overlapping one another by rotating the at least one wrapping arm (12) or the wrapping table;

**characterized in** that:

the at least one wrapping arm (12) is arranged such that a centre line ($F_{cl}$) of the foil (14) being stretched to the cylindrical object (15) is at an angle $\theta$ in a range between 15 and 45 degrees with the length axes of the support rollers (R1, R2, R3) and

the support rollers are arranged with a maximum relative length extension $R_e(N)$ as percentage of the length of the cylindrical object (15), as defined by the equation:

$$R_e(N) < 105 - 1.4\,\phi_N$$

where

$R_e(N)$ is the extension of the support roller (N) in question as a percentage of the length of the cylindrical object (15),

$\phi_N$ is the angular position of the support roller R(N) in degrees from a vertical line through the centre of the cylindrical object (15).

18. Foil wrapping device (10) as claimed in claim 17, comprising a plurality of wrapping arms.

19. Foil wrapping device (10) as claimed in claim 17 or claim 18, wherein the support rollers are in pairs.

20. Foil wrapping device (10) as claimed in any of claims 17 to 19, wherein the support rollers are powered.

21. Foil wrapping device (10) as claimed in any claims 17 to 20, wherein the device is configured to apply the foil across an edge of the cylindrical object.

22. Foil wrapping device (10) as claimed in any of claims 17 to 21, wherein the length extensions of the support rollers are within 80 to 100% of the calculated value for $R_e(N)$.

23. Foil wrapping device (10) as claimed in claim 22, wherein the length extensions of the support rollers are within 90 to 95% of the calculated value for $R_e(N)$.

24. Foil wrapping device as claimed in any of claims 17 to 23, comprising a pair of longer support rollers which support about 90% of the bale length.

25. Foil wrapping device (10) as claimed in any of claims 17 to 24, comprising a second, shorter support roller pair which support about 75% of the bale length.

26. Foil wrapping device (10) as claimed in any of claims 17 to 25, comprising a third support roller pair which support about 55% of the bale length.

27. Foil wrapping device (10) as claimed in any of claims 24 to 26, wherein the longer support rollers R1 are located on a radial line from the centre of the bale at an angle $\phi_1$ in the range 10 to 20 degrees from a vertical radial line $B_{vl}$ from the centre of the bale.

28. Foil wrapping device (10) as claimed in any of claims 25 to 27, wherein the second, shorter support rollers are located on a radial line from the centre of the bale at an angle $\phi_2$ in the range 20 to 30 degrees from a vertical radial line $B_{vl}$ from the centre of the bale.

29. Foil wrapping device (10) as claimed in any of claims 26 to 28, wherein the third support roller rollers located a radial line from the centre of the bale at an angle $\phi_3$ in the range 30 to 45 degrees from a vertical radial line $B_{vl}$ from the centre of the bale.

30. Foil wrapping device (10) as claimed in any of claims 17 to 29, wherein a centre line ($F_{cl}$) of the foil passes a centre point ($B_{cp}$) of the cylindrical object with a maximum deviation of less than 10 % of the diameter of the cylindrical object.

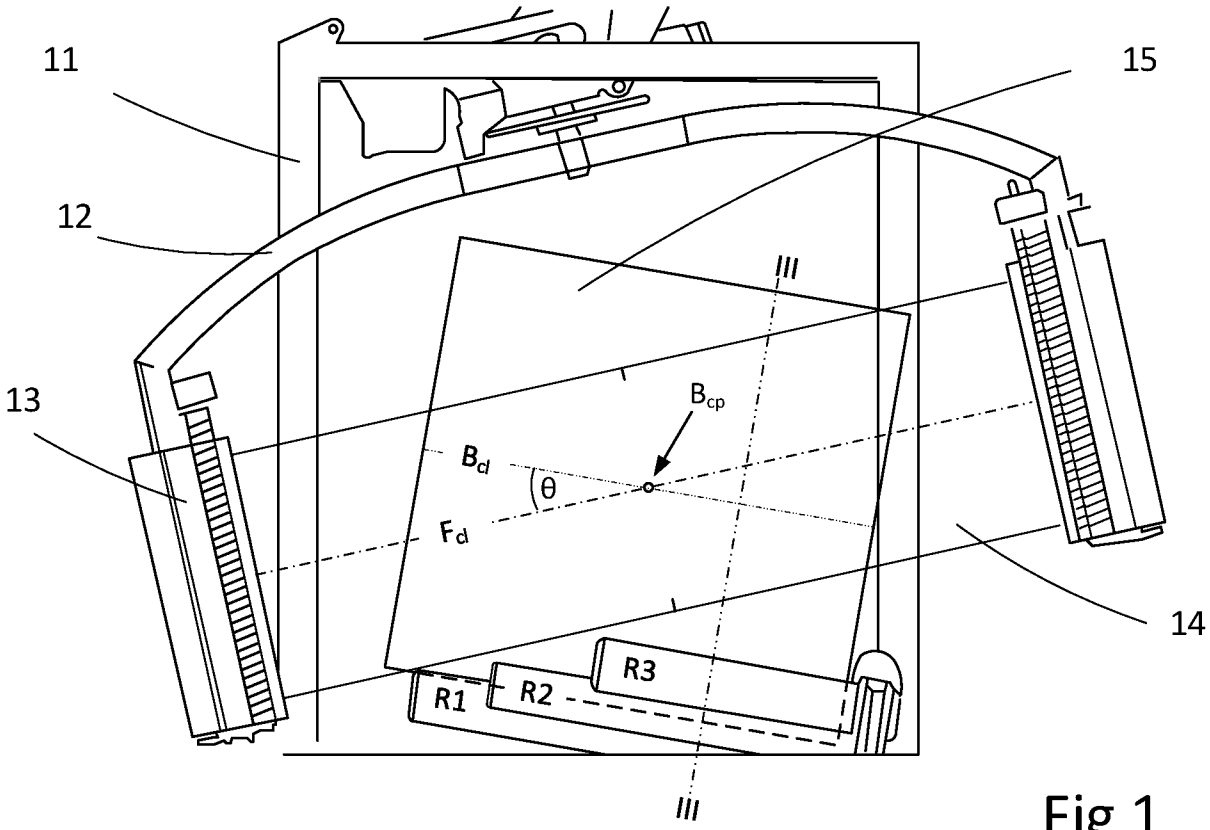
11
12
13
15
14
III
III
$B_{cp}$
$B_d$
θ
$F_d$
R1
R2
R3

Fig 1

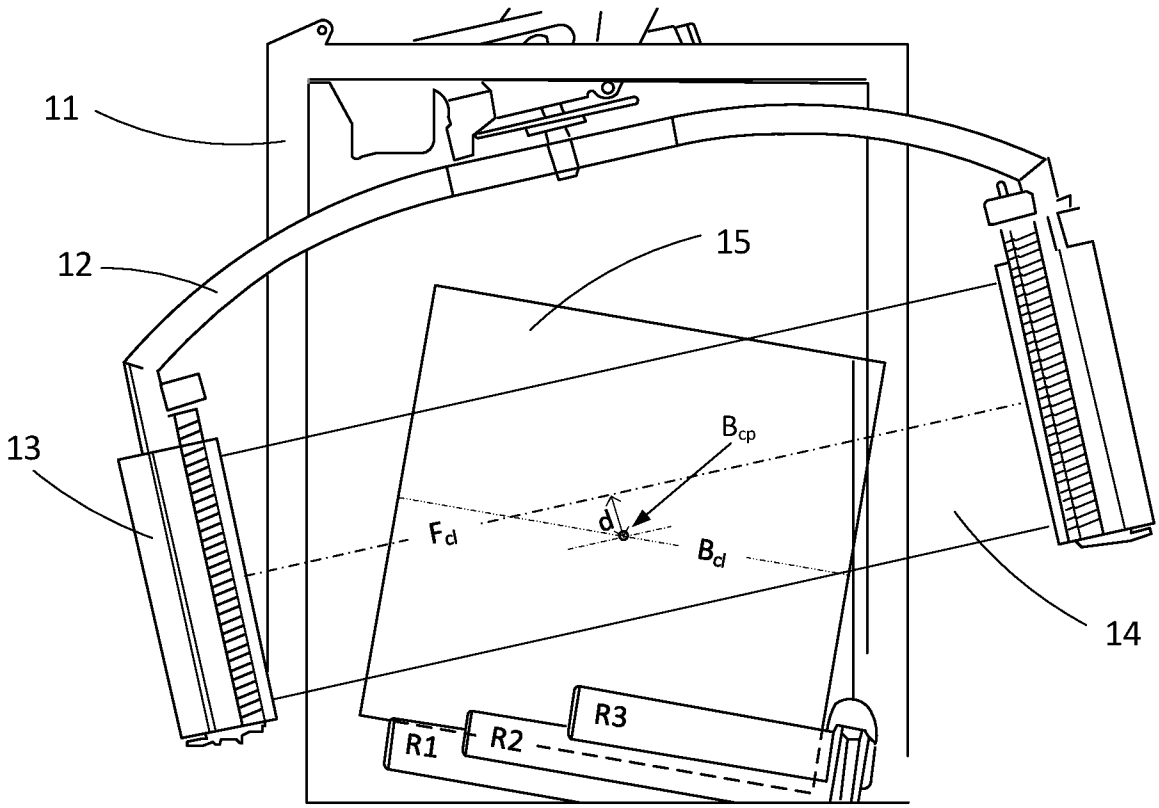
11
12
13
15
14
$B_{cp}$
d
$F_d$
$B_d$
R1
R2
R3

Fig 2

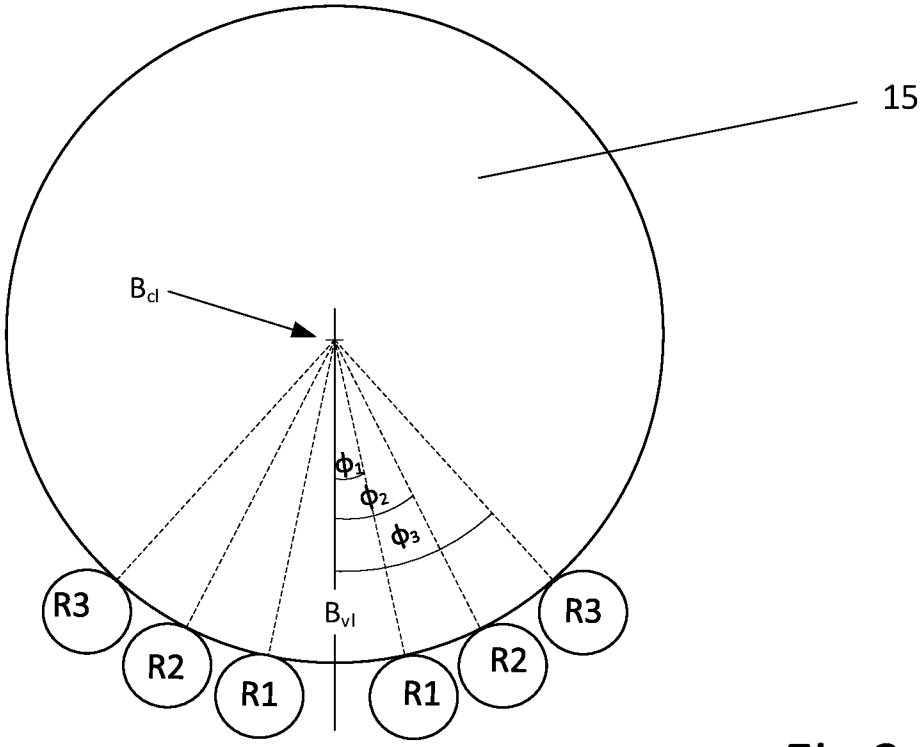
15
$B_{cl}$
$\phi_1$
$\phi_2$
$\phi_3$
R3
R2
R1
$B_{vl}$
R1
R2
R3

Fig 3

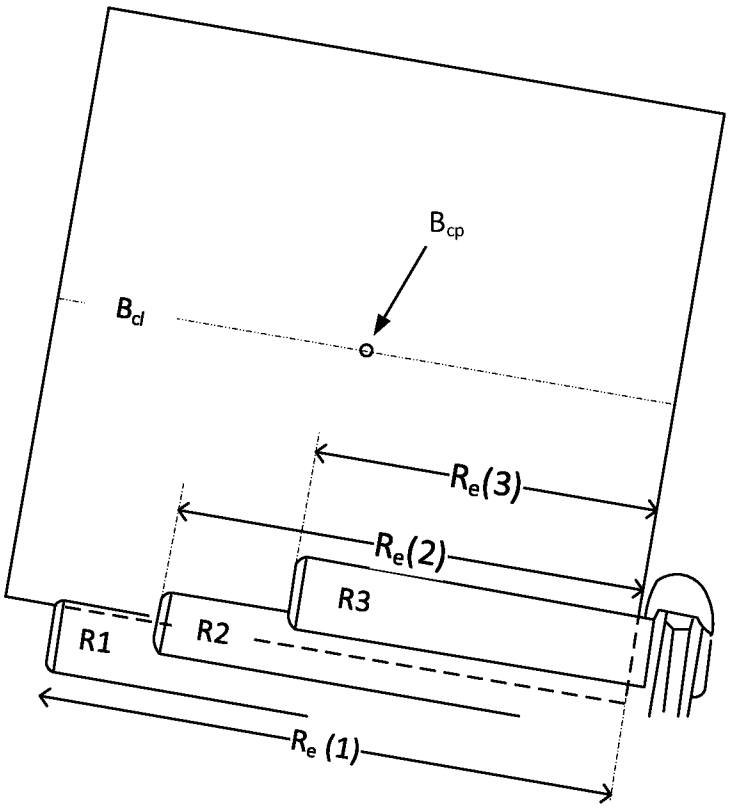
$B_{cp}$
$B_{cl}$
$R_e(3)$
$R_e(2)$
R3
R2
R1
$R_e$ (1)

Fig 4